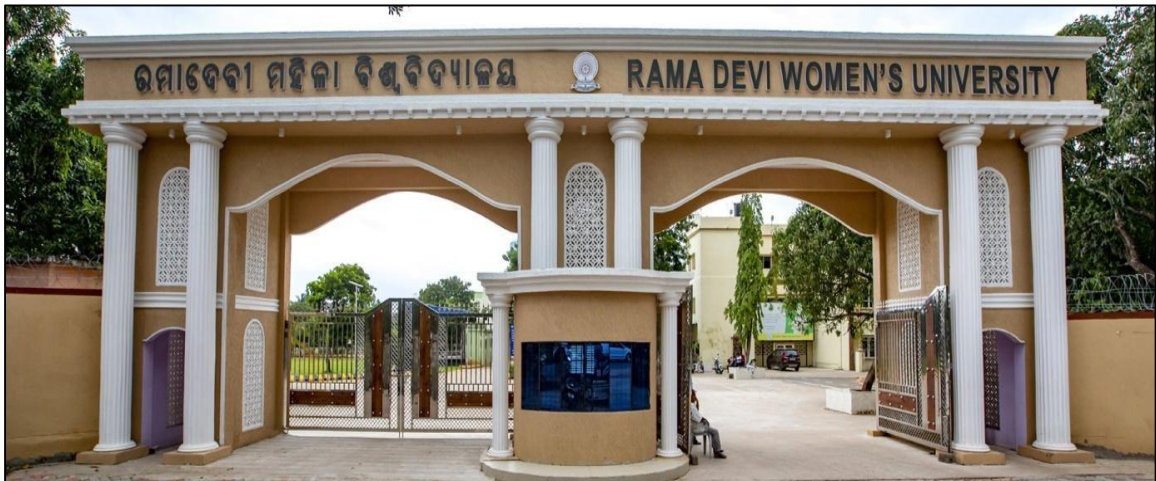


# DEPARTMENT OF ZOOLOGY

## SYLLABUS OF UG PROGRAMME (B.Sc.)



**RAMA DEVI WOMEN'S UNIVERSITY**  
Vidya Vihar, Bhubaneswar-751022, Odisha  
Website: <https://rdwu.ac.in>

SYLLABUS FOR UNDER GRADUATE  
COURSE IN  
**ZOOLOGY**  
(Bachelor of Science Examination)



*Manoj Kumar*  
20.10.23  
Controller of Examinations  
R.D. Women's University  
Bhubaneswar

RAMA DEVI WOMEN'S UNIVERSITY  
VIDYA VIHAR, BHUBANESWAR-22

UNDER CHOICE BASED CREDIT  
SYSTEM

<b>Course Structure of U.G. Zoology Honours</b>				
<b>Semester</b>	<b>Course</b>	<b>Course name</b>	<b>Credit</b>	<b>Total marks</b>
Semester-I	AECC I	AECC I	4	100
	Core I (Theory)	Non-chordates I:Protista to Pseudocoelomates	4	75
	Core I (Practical)	Non-chordates I:Protista to Pseudocoelomates	2	25
	Core II (Theory)	Principles of Ecology	4	75
	Core II (Practical)	Principles of Ecology	2	25
	GE 1(Theory)	GE 1(Theory)	4	75
	GE 1(Practical)	GE 1(Practical)	2	25
Semester-II	AECC 2	AECC-2	4	100
	Core III (Theory)	Non chordates II:Coelomates	4	75
	Core III (Practical)	Non chordates II:Coelomates	2	25
	Core IV(Theory)	Cell Biology	4	75
	Core IV(Practical)	Cell Biology	2	25
	GE II (Theory)	GE II (Theory)	4	75
	GE II(Practical)	GE II(Practical)	2	25
Semester III	Core V(Theory)	Diversity of Chordates	4	75
	Core V(Practical)	Diversity of Chordates	2	25
	Core VI(Theory)	Physiology:Controlling and Coordinating systems	4	75
	Core VI(Practical)	Physiology:Controlling and Coordinating systems	2	25
	Core VII(Theory)	Fundamentals of Biochemistry	4	75
	Core VII(Practical)	Fundamentals of Biochemistry	2	25
	SEC 1	SEC 1	4	100
	GE III(Theory)	GE III(Theory)	4	75
	GE III(Practical)	GE III(Practical)	2	25
Semester-IV	Core VIII(Theory)	Comparative anatomy of Vertebrates	4	75

	Core VIII(Practical)	Comparative anatomy of Vertebrates	2	25
	Core IX (Theory)	Physiology:Life Sustaining Systems	4	75
	Core IX (Practical)	Physiology:Life Sustaining Systems	2	25
	Core X (Theory)	Biochemistry of Metabolic Processes	4	75
	Core X (Practical)	Biochemistry of Metabolic Processes	2	25
	SEC 2	SEC 2	4	100
	GE IV(Theory)	GE IV(Theory)	4	75
	GE IV(Practical)	GE IV(Practical)	2	25
Semester- V	Core XI (Theory)	Molecular Biology	4	75
	Core XI (Practical)	Molecular Biology	2	25
	Core XII (Theory)	Principles of Genetics	4	75
	Core X II(Practical)	Principles of Genetics	2	25
	DSE I (Theory)	DSE I	4	75
	DSE I (Practical)	DSE I	2	25
	DSE II (Theory)	DSE II	4	75
	DSE II (Practical)	DSE II	2	25
Semester- VI	Core XIII (Theory)	Developmental Biology	4	75
	Core XIII (Practical)	Developmental Biology	2	25
	Core XIV(Theory)	Evolutionary Biology	4	75
	Core XIV(Practical)	Evolutionary Biology	2	25
	DSE III (Theory)	DSE III	4	75
	DSE III (Practical)	DSE III	2	25

	DSE IV(Theory with Practical/Project)	Project/Economic Zoology	6	100
<b>Total</b>			<b>148</b>	<b>2600</b>

### **Program Outcomes**

**After completion of B.Sc Zoology program offered by the Department of Zoology,RDWU, the students will be able to:**

**PO 1: Disciplinary Knowledge:** Demonstrate comprehensive knowledge and skills in areas related to Animal Kingdom, Ecology, Cell biology, Physiology ,Biochemistry ,Comparative Anatomy, Molecular Biology, Genetics , Developmental Biology, Evolution, Immunology, Animal Behaviour, Chronobiology, Fisheries, Economic Zoology and Nutritional Biology.

**PO 2: Communication Skills:** Various research and seminar themes of Zoology conducted during the Bachelor’s degree helps to communicate and publish the results of studies undertaken in the field(s) of accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s).

**PO 3: Critical Thinking and Problem solving:** Students are trained in various specialized subjects from the first semester onwards for evidence-based evaluation of practices, policies and theories using well-defined scientific approach to knowledge development.

**PO 4: Analytical Reasoning:** Students are trained to improve the ability to evaluate the reliability and relevance of evidence, identify logical flaws in the arguments of others, analyse and synthesize data from a variety of sources, and draw valid conclusions.

**PO 5: Research related skills:** Students are trained to demonstrate a sense of inquiry and capability for asking relevant/appropriate questions; the ability to recognise cause-andeffect relationships, define problems, formulate hypotheses, test hypotheses, analyse, interpret and draw conclusions from data; plan, execute and report the results of an experiment or investigation. Training in frontier areas of zoology helps the students to use knowledge and skills required for identifying problems and issues, collection of relevant quantitative and/or qualitative data, analysis and evaluation using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments.

**PO 6: Collaboration/Cooperation/Team work:** Practical and high-end techniques based B.Sc. courses train the students to demonstrate ability to work effectively with diverse teams, facilitate cooperative or coordinated effort on the part of a group, and act together as a group or a team in the interests of a common cause.

**PO 7: Information/Digital Literacy:** Practical and certain taught courses in Zoology train the students to demonstrate capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources and to use appropriate software for analysis.

**PO 8: Moral and Ethical Awareness/Reasoning:** Students acquire the ability to identify ethical issues related to research work, avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, appreciate environmental and sustainability issues, and adopt objective, unbiased and truthful actions in all aspects of work.

**PO 9: Leadership Readiness/Qualities:** Students of Animal Biology can demonstrate capability for mapping out where one needs to go to "win" as a team or an organization, formulate an inspiring vision, build a team who can help achieve the vision, motivate and inspire team members to engage with that vision, and use management skills to guide the team to the right destination.

**PO 10: Self Learning and Lifelong Learning:** Students of Zoology can demonstrate to acquire knowledge and skills, including 'learning how to learn' that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development and to meet the changing trades and demands of work place.

#### **PROGRAM SPECIFIC OUTCOMES (PSO):**

**PSO-1:** Students can pursue professional courses like M.Sc, DMLT courses, Graduate Diploma/Certificate courses and PhD.

**PSO-2:** Develop passion for research in various fields like molecular biology, immunology, genetics, cell biology, developmental biology, chronobiology, biochemistry etc

**PSO-3:** Acquire practical learning from projects, field visits and seminars.

**PSO-4:** Improve the observational, computational, and analytical ethical skills required for evolved trends in genetics, molecular biology, cell biology, etc.

### **Core Paper I**

#### **Non-Chordates I: Protista to Pseudocoelomates**

#### **COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Learn about the importance of general characteristics, classification and structural organization of different non chordate phyla.
- Appreciate the diversity of non-chordates living in varied habit and habitats. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

- The students will learn about the structure, life cycle and control of *Plasmodium*, *Entamoeba*, *Fasciola hepatica*, *Taenia solium*, *Ascaris lumbricoides* and *Wuchereria bancrofti*.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.

### **Unit 1: Protista, Parazoa, Metazoa and Porifera**

General characteristics and Classification up to classes. Study of Euglena, Amoeba. Life cycle and pathogenicity of Plasmodium vivax and Entamoeba histolytica. Locomotion and Reproduction in Protista. General characteristics and Classification up to classes, Canal system and spicules in sponges.

### **Unit 2: Cnidaria & Ctenophora**

General characteristics and Classification up to classes, Metagenesis in Obelia, Polymorphism in Cnidaria, Corals and coral reefs. General characteristics and Evolutionary significance of Ctenophora.

### **Unit 3: Platyhelminthes**

General characteristics and Classification up to classes. Life cycle and pathogenicity of Fasciola hepatica and Taenia solium.

### **Unit 4: Nematelminthes**

General characteristics and Classification up to classes. Life cycle, and pathogenicity of Ascaris lumbricoides and Wuchereria bancrofti. Parasitic adaptations in helminthes Note: Classification to be followed from “Barnes, R.D. (1982). Invertebrate Zoology, V Edition”

### **PRACTICAL**

1. Study of whole mount of Euglena, Amoeba and Paramecium, Binary fission and Conjugation in Paramecium.
2. Examination of pond water collected from different places for diversity in protista.
3. Study of Sycon (T.S. and L.S.), Hyalonema, Euplectella, Spongilla.
4. Study of Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora.
5. One specimen/slide of any ctenophore.
6. Study of adult Fasciola hepatica, Taenia solium and their life cycles (Slides/microphotographs).
7. Study of adult Ascaris lumbricoides and its life stages (Slides/micro-photographs).
8. To submit a Project Report on any related topic on life cycles/coral/ coral reefs.

## PRACTICAL COURSE OUTCOMES

Upon completion of the course, students should be able to:

- Understand and identify various protozoans from permanent slides.
- How to examine pond water for protista diversity.
- Identify invertebrate animal phyla like porifera, cnidaria, ctenophora, platyhelminthes and nemathelminthes from museum specimens and permanent slides.

Note: Classification to be followed from “Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition”

## TEXT BOOKS

Kotpal RL; Modern Textbook of Zoology – Invertebrates; Rastogi Publications - Meerut; 2016 edition  
2. Richard Busca, W. Moore, Stephen M. Shuster. Invertebrates; OUP USA; 3 edition (19 January 2016)

## SUGGESTED READINGS

1. Richard Fox, Robert D. Barnes, Edward E. Ruppert, Invertebrate Zoology: A Functional Evolutionary Approach, Brooks/Cole; 7th edition edition 2003
2. Barrington, E.J.W. Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.
3. Hyman, L.H. Invertebrate Series (Recent edition)
4. Verma P. S. A Manual of Practical Zoology: Invertebrates. S Chand Publication
5. Parker JJ and WA Haswel Textbook of Zoology. Vol I and II

## MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	5	4	2	2	2	4	4	5	5
CO2	5	4	2	2	4	4	2	2	2	5
CO3	5	5	2	2	4	4	2	2	2	5
CO4	5	5	2	4	4	4	2	4	4	5

- Note related: 1
- From What Related: 2
- Neutral: 3
- Moderately Related: 4
- Highly Related: 5



## **Core Paper II**

### **Principles of Ecology**

#### **COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors. Know about the types of ecosystems, food chains, food webs, energy models. Apply the basic principles of ecology in wildlife conservation and management.
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- The students gain knowledge and experience on handling biological, environmental, ecological data. The students gain knowledge on formulating and testing hypotheses. Students design sampling methods. Students extract genomic data and analyze it.

#### **Unit 1: Ecosystem and Applied Ecology**

Ecology: Autecology and synecology, Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Ecology in Wildlife Conservation and Management. Laws of limiting factors, Study of physical factors- (Light, temperature).

#### **Unit 2: Population**

Attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation - density-dependent and independent factors, Population interactions, Gause's Principle with laboratory and field examples.

#### **Unit 3: Community**

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological succession with one example. Theories pertaining to climax community.

#### **Unit – 4: Biometry**

Biological data, graphical representation of data (frequency polygon and histogram), sampling techniques, measures of central tendency (Mean, median and mode), Measures of

dispersion (range, quartile deviation, mean deviation and standard deviation), Hypothesis and hypothesis testing (Chi-square test, t- test)

## **PRACTICAL**

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton collection, preservation and mounting, Measurement of temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), BOD, COD, Free CO<sub>2</sub>, Hardness, TDS.
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.
5. Chi-square analysis using seeds/beads/Drosophila.
6. Problems on standard deviation.
7. Graphical representation of data (Frequency polygon and Histogram).

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Plot the survivorship curves of different types from the provided data.
- Determine the population density in a community by quadrat method and calculate Shannon-Weiner diversity index .
- Determine pH, dissolved oxygen content of water samples.
- Do the standard deviation problems.
- Represent the data in graphical forms.

## **Text Book**

Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition 2. Smith and Smith, Elements of Ecology, Global Edition; Pearson Education India; ninth edition (14 May 2015) 3. Myra Samuels, J. Witmer, A. Schaffner, Statistics for the life sciences, Prentice Halls, Boston, 4th edition, 2012

## **Suggested Readings**

1. Kormondy, (2017). Concepts of Ecology, Updated 4/e, Pearson 2. Colinviaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc. Krebs, C. J. (2001). Ecology.

VI Edition. Benjamin Cummings. 3. Ricklefs, R.E., (2000). Ecology. 5th Edition. Chiron Press 4. Dash M.C., Fundamentals of Ecology. Mc GrawHill 5. Smith TM and Smith RL, Elements of Ecology, 8th Edition, Pearson education INC, USA 6. Miller, G.T. and Spoolman, S.E. (2017) Environmental Science, 14th Edition. Cengage Publication, New Delhi. 7. Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition. 8. Cengage Publication, New Delhi 9. Web site: <https://www.cbd.int/> 10. Banerjee Pranab Kumar, Introduction to biostatistics, S Chand & Company; 3rd Rev. Edn. 2006 edition 11. Chainy GBN, Mishra G, MohantyPK, 2004, Basic Biostatistics, Kalyani Publisher

#### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	5	4	2	4	5	2	2	5	5	5
<b>CO2</b>	5	4	5	5	5	5	5	2	2	5
<b>CO3</b>	5	5	2	2	2	2	2	5	4	5
<b>CO4</b>	5	5	5	5	5	5	5	2	5	5

### **Core Paper III**

#### **Non- Chordates II: Coelomates**

#### **COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Learn about the characteristics of higher invertebrates. They should be able to represent the invertebrates of different categories which affect the ecosystem in various ways.
- Learn about the metamerism in Annelids,
- Analyze and learn the concept and types of metamorphosis in Arthropoda.
- Describe the social life in insects, torsion in Gastropods and water vascular system in Asterozoa.

Know about different larval forms and their evolutionary significance.

#### **Unit 1: Coelomates and Annelids**

Evolution of coelom and metamerism. General characteristics and Classification up to classes; Excretion in Annelida.

#### **Unit 2: Arthropoda and Onychophora**

General characteristics and Classification up to classes. Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites. Onychophora: General characteristics and Evolutionary significance.

#### **Unit 3: Mollusca**

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Evolutionary significance of trochophore larva.

#### **Unit 4: Echinodermata**

General characteristics and Classification up to classes. Water-vascular system in Asterozoa, Larval forms in Echinodermata, Affinities with Chordates.

Note: Classification to be followed from “Ruppert and Barnes (2006) Invertebrate Zoology, 8th edition, Holt Saunders International Edition”

### **PRACTICAL**

1. Study of following specimens:

2. Annelids - Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria

3. Arthropods – Tachypleus, Carinoscorpious, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta, termites and honey bees

4. Onychophora – Peripatus

5. Molluscs - Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus

6. Echinodermates - Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon

7. Study of digestive system, nephridia of earthworm (Virtual).

8. T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.

9. Mount of mouth parts and dissection of digestive system and nervous system of Periplaneta.

10. To submit a Project Report on any related topic to larval forms (crustacean, mollusc and echinoderm)

### **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Identify invertebrate animal phyla like Annelida, Arthropoda, Onychophora, Mollusca, Echinodermata from museum specimens.
- Identify the histological slides of digestive system of earth worm.

### **Text Books**

1. Kotpal RL (2014) Text book of Zoology, Invertebrate, Rastogi Publication
2. Jordan and Verma PS (2009) Invertebrate Zoology. S Chand publication. 9

### **Suggested Readings**

1. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.
2. Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science

3. Verma P S. (2010) A Manual of Practical Zoology: Non-chordates. S Chand Publication

### MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	2	2	4	5	2	4	5	4	5
CO2	5	2	2	4	5	4	4	5	4	5
CO3	5	2	2	2	5	2	4	4	4	5
CO4	5	2	2	4	5	2	4	5	5	5

### Core Paper IV Cell biology

#### COURSE OUTCOMES

Upon completion of the course, students should to be able to:

- Gain the knowledge about the organization in the prokaryotic and eukaryotic cell and explain structure and functions of cell organelles involved in diverse cellular processes.
- Know the structure and function of cytoskeleton and endomembrane system.
- Realize about the power house of cell and peroxisomes.
- Comprehend the process of cell signalling and its role in cellular functions.

#### Unit 1: Overview of cells and plasma membrane

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membranestructure. Transport across membranes: Active and Passive transport, Facilitated transport. Cell junctions: Tight junctions, Desmosomes, Gap junctions.

#### Unit 2: Cytoskeleton & Endomembrane System

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments; Structure and Functions: Endoplasmic Reticulum, Golgi apparatus, Lysosomes.

#### Unit 3: Mitochondria and Peroxisomes

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis; Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis. Peroxisomes.

#### Unit 4: Nucleus, Cell Division and Cell signalling

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus; Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome);

Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP)

## **Practical**

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Study of various stages of meiosis.
3. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
4. Preparation of permanent slide to demonstrate: i. DNA by Feulgen reaction ii. DNA and RNA by MGP iii. Mucopolysaccharides by PAS reaction iv. Proteins by Mercuric bromophenol blue/Fast Green
5. Demonstration of osmosis (RBC/ Egg etc.).

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should to be able to:

- Prepare the temporary stained squash of onion root tip to study stages of mitosis.
- Identify various stages of meiosis.
- Prepare the permanent slides to show the presence of Barr body in human female cheek cells.
- Experiment the osmosis process in RBC.

### **Text Books**

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. S Harisha (2007) Biotechnology procedures and experiments handbook., Infinity Science Press, Hingham 1 0

### **Suggested Readings**

1. Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.
2. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
3. Suvarna S, Lyton C, Bancroft JD (2013) Theory and practice of histological techniques, Churchill Livingstone, Elsevier, UK

4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA

**MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	5	2	2	4	4	4	2	4	4	5
<b>CO2</b>	5	2	2	4	5	4	2	4	4	5
<b>CO3</b>	5	2	2	2	5	4	2	4	4	5
<b>CO4</b>	5	2	4	4	5	4	2	4	4	5

**Core Paper V**

**Diversity and distribution of Chordates**

**COURSE OUTCOMES**

Upon completion of the course, students should to be able to:

- Understand about hemichordates, urochordates and cephalochordates, their larval forms and concept of origin of chordates.
- Comprehend the general characteristics, classification of cyclostomes, fishes, their migration, parental care in fishes and amphibians, evolutionary significance of Dipnoi and origin of Tetrapoda.
- Know the general characteristics, classification of Reptiles and Birds, poisonous apparatus of Snakes, flight adaptation and migration in Birds.
- Appreciate general characters, classification of Mammals, their adaptive radiations and distribution of vertebrates in different zoogeographical realms.

**Unit 1: Protochordates and Origin of Chordates**

Protochordata: General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata. General characteristics and outline classification Chordata. Dipleurula concept and the Echinoderm theory of origin of chordates.

**Unit 2: Agnatha, Pisces & Amphibia**

General characteristics of Agnatha: General characteristics and classification of cyclostomes up to class Chondrichthyes and Osteichthyes: classification up to order, Migration, Parental care in fishes, Accessory respiratory organs in pisces, Evolutionary significance of Dipnoi. Amphibian: Origin of Tetrapoda (Evolution of terrestrial ectotherms); General characteristics and classification up to order. Parental care in Amphibia.

### **Unit 3: Reptilia & Aves**

General characteristics and classification up to order in reptiles; Affinities of Sphenodon; Poison apparatus and Biting mechanism in snakes. General characteristics and classification up to order in Aves Archaeopteryx - a connecting link; Flight adaptations and Migration in birds.

### **Unit 4: Mammals & Zoogeography**

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages. Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

## **PRACTICAL**

1. Protochordata: Balanoglossus, Herdmania, Branchiostoma, Colonial Urochordata, Sections of Balanoglossus through proboscis and branchio-genital regions, Sections of Amphioxus through pharyngeal, intestinal and caudal regions. Permanent slides of Herdmania spicules.
2. Agnatha: Petromyzon and Myxine.
3. Fishes: Scoliodon, Sphyrna, Pristis, Torpedo, Chimaera, Mystus, Heteropneustes, Labeo, Exocoetus, Echeneis, Anguilla, Hippocampus, Tetrodon/Diodon, Anabas, Flat fish.
4. Amphibia: Ichthyophis/Ureotyphlus, Necturus, Bufo, Hyla, Alytes, Salamander.
5. Reptilia: Chelone, Trionyx, Hemidactylus, Varanus, Uromastix, Chamaeleon, Ophiosaurus, Draco, Bungarus, Vipera, Naja, Hydrophis, Zamenis, Crocodylus  
Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws. Study of feathers.
7. Mammalia: Sorex, Bat (Insectivorous and Frugivorous), Funambulus, Loris, Herpestes, Erinaceus.
8. Power point presentation on study of any two animals from two different classes by students. Submission of album of local species.

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Identify the permanent slides of Protochordates
- Identify different specimens of Fishes, Amphibians, Reptiles, Aves and Mammals.



### TEXT BOOKS

1. Kotpal RL; Modern Textbook of Zoology –Vertebrates; Rastogi Publications - Meerut; 2016 edition
2. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.
3. Tiwari SK (2006) Fundamentals of World Zoogeography, Sarup & Sons

### SUGGESTED READINGS

1. Pough H. Vertebrate life, VIII Edition, 2007 Pearson International.
2. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.
3. Hickman CP, Roberts LS, Keen S, Larson A, P'Anson H, Isenhour DJ Integrated Principle of Zoology, 14th edition, 2008, McGrawHill publication
4. Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. S Chand Publication.

### MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	2	4	2	2	4	5	4	5
CO2	5	4	2	4	4	2	4	5	4	4
CO3	5	2	2	4	2	2	4	5	5	5
CO4	5	2	2	4	4	2	4	5	4	5

### Core Paper VI

#### Physiology: Controlling and Coordinating Systems

### COURSE OUTCOMES

Upon completion of the course, students should be able to:

- Know the structure, classification and function of different tissues.
- Comprehend the molecular basis of muscle contraction, structure of muscles and neurons, synaptic transmission and physiology of hearing and vision.
- Appreciate the physiology of male and female reproductive systems, methods of contraception in male and female.
- Comprehend the endocrine glands, their secretions and mechanism of hormone action.

## **Unit 1: Tissues & Tissue system**

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue. Structure and types of bones and cartilages, Ossification, bone growth and resorption.

## **Unit 2: Muscle & Nervous System**

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction. Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc; Physiology of hearing and vision.

## **Unit 3: Reproductive System**

Histology of testis and ovary; Physiology of male and female reproduction; Hypothalamus Pituitary & Gonadal axis. Puberty, Ovarian Cycle, Methods of contraception in male and female, Placental hormones.

## **Unit 4: Endocrine System**

Histology of endocrine glands – Hypothalamus (Neuroendocrine gland) pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action; Classification of hormones and mechanism of hormone action, (steroidal and nonsteroidal hormones).

## **PRACTICAL**

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex).
2. Study of permanent slides- Squamous epithelium, Striated muscle fibres and nerve cells.
3. Study of permanent slides-Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid.
4. Microtomy: Preparation of permanent slides/photographs/computer models of any five types of mammalian (Goat/rat,etc) tissues

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should to be able to:

- Know unconditioned reflex action experimentally.
- Identify the different histological slides of different tissues and endocrine glands.

## TEXT BOOKS

1. Marieb EN and Hoehn K, Human Physiology,(2013), 9th edition, Pearson Education, USA. 2. Endocrinology, Hadley ME and Levine JE (2009), Pearson Education India; 6 edition 3. Textbook of Medical Physiology, Guyton & Hall, Elsevier, 12th edition, 2016

## SUGGESTED BOOKS

1. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition., Lippincott W. & Wilkins
2. Martini F H, Nath J L and Bartholomew E F.(2015) Fundamentals of Anatomy and Physiology. Pearson Education Publication,
3. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hecourt Asia PTE Ltd. /W.B.Saunders Company
- . 4. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.

### MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	5	5	4	2	4	4	5	5
CO2	5	4	5	5	4	2	4	4	5	5
CO3	5	4	4	5	5	2	4	4	5	5
CO4	5	4	4	5	5	2	4	4	5	5

## Core Paper VII

### Fundamentals of Biochemistry

#### COURSE OUTCOMES

Upon completion of the course, students should be able to:

- Understand the biological importance of carbohydrates and fats.
- Realize the building blocks of protein, their physiological importances and structure and function of different important proteins.
- Know about different components of nucleic acids and their properties.
- Comprehend about the biocatalysts, their types, mechanism of their action, graphical representation, regulation of their action.

#### Unit 1: Carbohydrates & Lipids

Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

### **Unit 2: Proteins Amino acids:**

Structure, Classification and General properties of  $\alpha$ -amino acids; Physiological importance of essential and non-essential  $\alpha$ -amino acids. Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Renaturation, Denaturation; Introduction to simple and conjugate proteins Immunoglobulins: Basic Structure, Classes and Function, Antigenic Determinants.

### **Unit 3: Nucleic Acids Structure**

: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids Cot Curves: Base pairing, Denaturation and Renaturation of DNA, Types of DNA and RNA, Complementarity of DNA, Hypo-Hyperchromaticity of DNA. 12

### **Unit 4: Enzymes**

Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of  $K_m$  and  $V_{max}$ , Lineweaver Burk plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme action.

## **PRACTICAL**

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase./Urease/acid or alkaline phosphatase
5. Demonstration of proteins separation by SDS-PAGE.

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should to be able to:

- Analyze functional groups in carbohydrates, proteins and lipids.
- Perform the paper chromatography of amino acids.
- Know the action of salivary amylase under optimum conditions.

- Understand the effect of pH, temperature and inhibitors on the action of salivary amylase.

## TEXT BOOKS

1. Satyanarayan and Chakrapani , (2017) Biochemistry, Elsevier; Fifth edition
2. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
3. Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto, Biochemistry, 8th edition, 2015.
4. Victor W., Rodwell, David A., Bender, Kathleen M., Botham, Peter J., Kennelly, P. Anthony, Harper's Illustrated Biochemistry, 31st edition.

## SUGGESTED READING

1. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Publication.
3. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
4. Devasena T. (2010). Enzymology Oxford University Press; 1 edition
5. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.

## MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	5	4	5	4	4	4	2	4	5
CO2	5	5	5	5	5	4	4	4	4	4
CO3	5	4	4	5	5	4	4	2	4	4
CO4	5	4	5	5	5	4	4	2	4	4

## **Core Paper VIII**

### **Comparative Anatomy of Vertebrates**

#### **COURSE OUTCOME**

Upon completion of the course, students should be able to:

- Understand the pattern of vertebrate evolution, organisation and functions of various systems.
- Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.
- Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
- Learn the evolution of brain, sense organs and excretory organs to a complex, highly evolved form in mammals;

#### **Unit 1: Integumentary & Skeletal System**

Structure, functions and derivatives of integument (Scale, claw, nail, hair, feather and dentition). Axial and appendicular skeleton, Jaw suspensorium, Visceral arches.

#### **Unit 2: Digestive & Respiratory System**

Alimentary canal and associated glands; Respiration through Skin, gills, lungs and air sacs; Accessory respiratory organs.

#### **Unit 3: Circulatory and Urinogenital system**

General plan of circulation, evolution of heart and aortic arches; Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

#### **Unit 4: Nervous System & Sense Organs**

Comparative account of brain; Nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors: Brief account of visual and auditory receptors in man. Chemo and mechano receptors

## **PRACTICAL**

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, Varanus, Fowl, Rabbit.
3. Carapace and plastron of turtle /tortoise (Photographs, charts etc).
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) from video recording (may be included if dissection not permitted).
6. Project on skeletal modifications in vertebrates (may be included if dissection not permitted).

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should to be able to:

- Know different types of scales through permanent slides.
- Identify disarticulated bones of Frog, Varanus, Fowl and Rabbit.
- Understand the carapace and plastron of turtle.
- Identify the Mammalian skull.

## **TEXT BOOKS**

1. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education
2. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
3. R. K. Saxena and Sumitra Saxena (2016). Comparative Anatomy of Vertebrates 2nd edition.

## **SUGGESTED READINGS**

1. Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate tructure, John Wiley and Sons
2. Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House

### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
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<b>CO1</b>	5	5	5	5	4	2	2	4	4	5
<b>CO2</b>	4	5	4	5	4	2	2	4	4	5
<b>CO3</b>	5	5	4	5	4	2	2	4	4	5
<b>CO4</b>	5	5	4	5	4	4	2	4	4	5

## **Core Paper IX**

### **Physiology: Life Sustaining Systems**

#### **COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Understand the structure, function of digestive system and associated glands, process of digestion, absorption and hormonal control of gastric secretions.
- Comprehend the mechanism of respiration, transport of oxygen, carbon dioxide, dissociation curve and control of respiration.
- Realise the structure, function of kidney, regulation of acid base balance, blood components and blood groups.
- Know the structure, working of conducting myocardial fibers, cardiac cycle, cardiac outputs and its regulation and also blood pressure and its regulation.

#### **Unit 1: Physiology of Digestion**

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

#### **Unit 2: Physiology of Respiration**

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration. 14

#### **Unit 3: Renal Physiology and Blood**

Structure of kidney and its functional unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance. Components of blood and their functions; Structure and functions of haemoglobin haemostasis: Haemopoiesis, Blood clotting system, Blood groups: Rh factor, ABO and MN.

#### **Unit 4: Physiology of Heart**



Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation.

## **PRACTICAL**

1. Determination of ABO Blood group
2. Enumeration of red blood cells and white blood cells using haemocytometer
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals
5. Recording of blood pressure using a sphygmomanometer
6. Examination of sections of mammalian slides: oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.

## **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should be able to:

- Determine the ABO blood group.
- Enumerate the RBC and WBC using haemocytometer.
- Estimate haemoglobin using haemoglobinometer.
- Prepare haemin crystals.
- Record the blood pressure using sphygmomanometer.
- Analyse the histological sections of mammalian digestive, respiratory and excretory system.

## **TEXT BOOKS**

1. Marieb E.N. and Hoehn K.N. (2009) Human Physiology. Pearson Education Publication , 9th edition
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI 3. Edition John Wiley & sons.
4. Guyton & Hall, (2016) Textbook of Medical Physiology. Elsevier, 12th edition,

## **SUGGESTED READINGS**

1. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
2. Vander A Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.

3. Moyes C.D., Schulte PM (2016), Principles of physiology, 2nd edition, Pearson education, 3rd.

4. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company

#### MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

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CO1	5	4	5	5	5	5	2	2	4	5
CO2	5	4	5	5	5	5	4	2	4	5
CO3	5	4	4	5	5	5	4	2	4	5
CO4	5	4	4	5	5	5	4	2	4	5

### Core Paper X

#### Biochemistry of Metabolic Processes

#### COURSE OUTCOMES

Upon completion of the course, students should be able to:

- Understand the catabolism, anabolism, compartmentalization of metabolic pathways, energy currency of cell and regulatory mechanisms.
- Realize the different carbohydrate metabolisms like glycolysis, citric acid cycle, gluconeogenesis and glycogenesis.
- Comprehend the oxidation and biosynthesis of fatty acids, catabolism of amino acids and fate of the carbon skeletons of different amino acids.
- Know the mitochondrial respiratory chain and inhibitors of electron transport chain.

#### Unit 1: Overview of Metabolism

Catabolism vs Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

#### Unit 2: Carbohydrate Metabolism

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

#### Unit 3: Lipid and protein Metabolism

$\beta$ -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

#### **Unit 4: Oxidative Phosphorylation**

Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers of Electron Transport System

#### **PRACTICAL**

1. Estimation of total protein in given solutions
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
3. To study the enzymatic activity of Trypsin/ Lipase.
4. To perform the Acid and Alkaline phosphatase assay from serum/ tissue
5. Dry Lab (Virtual): To trace the labelled C atoms of Acetyl-CoA till they evolve as CO<sub>2</sub> in the TCA cycle.

#### **PRACTICAL COURSE OUTCOMES**

Upon completion of the course, students should to be able to:

- Estimate the total protein in a given solution.
- Detect the SGOT and SGPT in serum.
- Study the enzymatic activity of trypsin.
- Perform the acid and alkaline phosphatase assay from tissue.

#### **TEXT BOOKS**

1. Satyanarayan and Chakrapani , (2017) Biochemistry, Elsevier; Fifth edition.
2. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.

#### **SUGGESTED READINGS**

1. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007).Biochemistry, VI Edition, W.H. Freeman and Co., New York. 3. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K

## MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	5	5	4	4	2	2	4	5
CO2	5	4	5	5	5	4	4	4	4	5
CO3	5	4	5	5	5	4	4	2	4	5
CO4	5	4	5	5	5	4	2	4	4	5

### Core Paper XI

#### Molecular Biology

#### COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes.
- Describe the basic structure and chemistry of nucleic acids, DNA and RNA
- Explain post-transcriptional modification mechanisms for the processing of eukaryotic RNA.
- Gain knowledge about gene silencing through RNA interference and its application.

#### Unit 1: Nucleic Acids, DNA Replication & Repair

Salient features of DNA and RNA. Watson and Crick model of DNA. DNA Replication in prokaryotes and eukaryotes, mechanism of DNA replication, Semi-conservative, bidirectional and semi-discontinuous replication, RNA priming, Replication of circular and linear dsDNA, replication of telomeres. Pyrimidine dimerization and mismatch repair.

#### Unit 2: Transcription & Translation

RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors and regulation of transcription. Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; Process of protein synthesis in prokaryotes: Ribosome structure and assembly in prokaryotes, fidelity of protein synthesis, aminoacyl tRNA synthetases and charging of tRNA; Proteins involved

in initiation, elongation and termination of polypeptide chain; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation.

### **Unit 3: Post Transcriptional Modifications and Processing of Eukaryotic RNA**

Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of tRNA.

### **Unit 4: Gene Regulation & Regulatory RNAs**

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from lac operon and trp operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, RNA interference, miRNA, siRNA.

## **PRACTICAL**

1. Study of Polytene chromosomes from Chironomous / Drosophila larvae
2. Preparation of liquid culture medium (LB) and raise culture of E. coli
3. Estimation of the growth kinetics of E. coli by turbidity method
4. Preparation of solid culture medium (LB) and growth of E. coli by spreading and streaking
5. Quantitative estimation of salmon sperm/calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A<sub>260nm</sub> measurement)
6. Quantitative estimation of RNA using Orcinol reaction
7. Study and interpretation of electron micrographs/ photograph showing (a) DNA replication, (b) Transcription and (c) Split genes.

## **PRACTICAL COURSE OUTCOMES**

- Quantitatively estimate RNA using Orcinol reaction.
- Study and interpret electron micrograph showing.
- Prepare and study of liquid culture medium and raise culture of *E.coli*
- Demonstrate practical knowledge on polytene chromosomes from Chiromonas/Drosophila larvae.

## **TEXT BOOKS**

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
2. Lewin B. (2013). Gene XI, Jones and Bartlett.
3. De Robertis E.D.P. (2017) Cell and Molecular Biology 8Ed.
4. Arnold Berk , Chris A. Kaiser, Harvey Lodish , Angelika Amon , HiddePloegh, Anthony Bretscher, Monty Krieger Kelsey C. Martin(2016) Molecular Cell Biology. 8th edition

## **SUGGESTED READINGS**

1. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: Molecular Biology of the Cell, IV Edition.
3. Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
4. McLennan A., Bates A., Turner, P. and White M. (2015). Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.

#### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	5	4	5	5	5	4	5	2	4	4
<b>CO2</b>	5	4	5	4	5	4	4	2	4	4
<b>CO3</b>	5	4	5	5	4	4	4	2	4	5
<b>CO4</b>	5	4	5	5	4	4	4	2	4	5

### **Core Paper XII**

#### **Principles of Genetics**

#### **COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Have a deeper understanding of principles of inheritance, linkage, crossing over and chromosomal mapping.
- Know the mechanisms of mutations and its molecular basis and methods of detection of mutations.
- Explain Sex Determination in *Drosophila* and Man and Extra-chromosomal inheritance.
- Elucidate Recombination in bacteria and viruses and learn about transposable genetic elements.

#### **Unit 1: Mendelian Genetics, Linkage, Crossing Over and Chromosomal Mapping**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance. Polygenic inheritance with suitable examples; simple numericals based on it. Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

## **Unit 2: Mutations**

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached X method.

## **Unit 3: Sex Determination & Extra-chromosomal Inheritance**

Chromosomal mechanisms of sex determination in *Drosophila* and Man; Criteria for extrachromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces*, Infective heredity in *Paramecium* and Maternal effects.

## **Unit 4: Recombination in Bacteria and Viruses & Transposable Genetic Elements**

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in human.

## **PRACTICAL**

1. Study of Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.

## **PRACTICAL COURSE OUTCOMES**

- Study Mendelian laws and gene interactions and describe.
- Analyse pedigree of some human inherited traits.
- Perform Linkage maps study based on *Drosophila* crosses.

Perform Linkage maps study based on data from conjugation, transformation and transduction

### TEXT BOOKS

1. Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freeman publication
2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition.

### SUGGESTED READINGS

1. Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B.Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.
4. Fletcher H. and Hickey I. (2015). Genetics. IV Edition. GS, Taylor and Francis Group, New York and London.

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CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	4	5	5	4	2	4	4	5
CO2	5	4	5	4	4	4	2	4	4	5
CO3	5	4	5	5	4	4	2	4	4	5
CO4	5	4	4	4	5	4	2	4	4	5

### Core Paper XIII

#### Developmental Biology

#### COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Understand the events in gametogenesis and fertilization and historical perspective of phases of development.
- Describe early embryonic development in terms of cleavage and types of blastula.
- Discuss the fate of germ layers and late embryonic development.
- Learn importance of latest techniques like stem cell therapy and concepts of ageing, teratogenesis and regeneration

#### Unit 1: Introduction to Developmental Biology, Gametogenesis & Fertilization



Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division. Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy.

### **Unit 2: Early Embryonic Development**

Cleavage: Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

### **Unit3: Late Embryonic Development**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

### **Unit 4: Post Embryonic Development & Implications of Developmental Biology**

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories. Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis.

## **PRACTICAL**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
4. Study of different sections of placenta (photomicrograph/ slides).
5. Project report on *Drosophila* culture/chick embryo development.
6. Study of developmental stages by raising chick embryo in the laboratory

## **PRACTICAL COURSE OUTCOMES**

- Study and analyse whole mounts of developmental stages of chick through permanent slides.
- Analyse the developmental stages and life cycle of *Drosophila* from stock culture.
- Study whole mounts and sections of developmental stages of frog through permanent slides.
- Study different sections of placenta(photomicrographs/slides)

## **TEXT BOOKS**

1. Lewis Wolpert (2010). Principles of Development. II Edition, Oxford University Press.

2. Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.

#### **SUGGESTED READINGS**

1. Carlson, R. F. Patten's Foundations of Embryology.

2. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.

3. Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).

#### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	5	4	2	5	5	4	2	4	4	5
<b>CO2</b>	5	4	2	2	4	4	2	4	4	5
<b>CO3</b>	5	4	2	2	5	4	2	4	4	5
<b>CO4</b>	5	4	2	5	5	4	2	4	4	5

### **Core Paper XIV Evolutionary Biology**

#### **COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Gain knowledge about evolutionary concept of Lamarckism, Darwinism and extinctions.
- Acquire problem solving and high order analytical skills by attempting numerical problems on population genetics related evolutionary changes.
- Know the species concept and how adaptation led to evolution using Galapagos finches.
- Discuss the origin and evolution of man , about phylogenetic trees its construction and interpretation.

#### **Unit 1: Theories, Evidences of Evolution and Extinction**

Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, NeoDarwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Sources of variations: Heritable variations and their role in evolution. Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction.

## **Unit 2: Process of Evolutionary changes**

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection). Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies.

## **Unit 3: Species concept and Speciation**

Product of evolution: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Parapatric. Adaptive radiation / macroevolution (exemplified by Galapagos finches);

## **Unit 4: Concept of Origin and Evolution of man**

Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from Dryopithecus leading to Homo sapiens, molecular analysis of human origin. Phylogenetic trees, Multiple sequence alignment, construction and interpretation of phylogenetic trees.

## **PRACTICAL**

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.
6. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.

## **PRACTICAL COURSE OUTCOMES**

- Interpret and graphically represent data of height/weight of sample human
- Learn about natural selection and genetic drift through sample study.
- Study and interpret about different fossils.
- Practically verify Hardy-Weinberg Law by Chi square analysis.

## **TEXT BOOKS**

1. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
2. Rastogi B.B., (2018). Organic Evolution, MedTech; 3 rd edition

**SUGGESTED READINGS**

1. B.K. and Hallgrimson, B. (2008). Evolution IV Edition. Jones and Barlett Publishers.
2. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates. Snustad. S Principles of Genetics.
3. Ridley, M (2004) Evolution III Edition Blackwell publishing Hall.

**MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	4	4	2	2	5	4	4	5
CO2	5	4	4	4	4	2	4	4	4	5
CO3	5	4	2	4	4	2	2	4	4	5
CO4	5	4	2	4	2	2	2	4	4	5

**Discipline Specific Elective Paper-1  
Animal Behaviour and Chronobiology**

**COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Know about history of ethology and types of behaviour and stimulus filtering.
- Discuss about patterns of behaviours , learning and conditioning.
- Find out about communication and senses ,foraging in honey bees and sexual selection.
- Have a deeper understanding of biological oscillation. Circadian rhythms ,photoperiod and reproductive regulation in vertebrates.

**Unit 1: Animal Behaviour**

Origin and history of Ethology; Brief profiles of Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate behavior; Objective of behaviour, Behaviour as a basis of evolution; Behaviour as a discipline of science; Innate behaviour, Instinct, Stimulus filtering, Sign stimuli and Code breakers.

**Unit 2: Patterns of Behaviour**

Stereotyped Behaviours (Orientation, Reflexes); Individual behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting.

**Unit 3: Social and Sexual Behaviour**

Social Behaviour: Concept of Society; Communication and the senses; Altruism; Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance. Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Sexual conflict in parental care. 21

#### **Unit 4: Chronobiology**

Historical developments in chronobiology; Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks, Relevance of biological clocks, Types and characteristics of biological rhythms: Short- and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin.

#### **PRACTICAL**

1. To study nests and nesting habits of the birds and social insects.
2. To study the behavioural responses of wood lice in dry and humid condition.
3. To study geotaxis behaviour in earthworm.
4. To study the phototaxisbehaviour in insect larvae.
5. Study and actogram construction of locomotor activity of suitable animal models.
6. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
7. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioral activities of animals and prepare a short report.

#### **PRACTICAL COURSE OUTCOMES**

- Study and learn about nesting habits of birds and social insects.
- Practically study geotaxis behaviour in earthworm.
- Analyse and learn about circadian functions in humans.
- Study Phototaxis behaviour in insect larvae.

#### **TEXT BOOKS**

1. John A (2009) Animal Behaviour.9th edition, Sinauer Associate Inc., USA.
2. Vinod Kumar (2002) Biological Rhythms: Narosa Publishing House, Delhi/ SpringerVerlag, Germany.

#### **SUGGESTED READINGS**

1. AK Pati. Chronobiology: The Dimension of Time in Biology and Medicine. PINSA (Biological Sciences). Part B 67 (6). 323-372, Dec., 2001.
2. David McF. Animal Behaviour. Pitman Publishing Limited, London, UK.
3. Manning A and Dawkins MS. An Introduction to Animal Behaviour. Cambridge University Press, USA.
4. Paul WS and John A (2013) Exploring Animal Behaviour. 6th Edition. Sinauer Associate Inc., Massachusetts, USA.

5. Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Chronobiology Biological Timekeeping: J, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.

**MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	5	5	2	4	5	4	4	2	4	5
<b>CO2</b>	5	5	2	4	4	4	2	2	4	5
<b>CO3</b>	5	5	4	4	4	4	2	2	4	5
<b>CO4</b>	5	4	4	4	5	4	2	2	4	5

**Discipline Specific Elective Paper-1  
Immunology**

**COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity.
- Explain the properties of antigenicity and immunogenicity and study about antigen-antibody interactions.
- Define the cellular pathways of humoral responses including role of Major Histocompatibility Complex.
- Integrate knowledge of each subsystem of hypersensitivities and types of vaccines and their advancement.

**Unit 1: Innate and Adaptive Immunity**

Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to Rheumatoid Arthritis and tolerance, AIDS).

**Unit 2: Antigens and Immunoglobulins**

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA Direct, Indirect, Competitive, Sandwich and RIA)

### **Unit 3: Major Histocompatibility Complex, Cytokines and Complement system**

Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation; Cytokines -Properties and functions of cytokines, Therapeutics Cytokines Complement System -Components and pathways of complement activation.

### **Unit 4: Hypersensitivity and Vaccines**

Gell and Coombs' classification and brief description of various types of hypersensitivities Vaccines -various types of vaccines, Advances in vaccine production.

### **PRACTICAL**

1. Study of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of White blood cells.
4. ABO blood group determination.
5. Total WBC counting.
6. Demonstration of ELISA.
7. Demonstration of Bone marrow smears to study Immune cells.

### **PRACTICAL COURSE OUTCOMES**

- Analyse and study of spleen ,thymus and lymph nodes through slides/photograph and discuss their roles in immune system.
- Demonstrate and study bone marrow smears and know about different practical applications.
- Demonstrate and learn ELISA technique and its application.
- Prepare and study blood film and gain knowledge about WBC.

### **TEXT BOOKS**

2. Abbas K. Abul and Lechtman H. Andrew (2017) Cellular and Molecular Immunology. V Edition. Saunders Publication.
3. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kubly, J (2017). Immunology, VI Edition. W.H. Freeman and Company.

### **SUGGESTED READINGS**

1. Peter J. Delves and Seamus J. Martin (2017) Roitt's Essential Immunology, WileyBlackwell; 13th edition 27

### MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	5	4	5	2	4	2	4	5
CO2	5	4	5	4	5	2	4	2	4	5
CO3	5	4	5	4	5	2	4	2	4	4
CO4	5	4	5	5	5	2	4	2	4	5

### Discipline Specific Elective Paper-III Fish and Fisheries

#### COURSE OUTCOMES

Upon completion of this course, students will be able to:

- Describe locomotion in fishes, role of gills and gas exchange and know phenomenon of schooling and migration.
- Know about different types of fisheries and about depletion of fisheries resources.
- Learn about sustainable aquaculture management and maintenance of fish aquarium and hatcheries.
- Understand and about different pathogens causing fish diseases and relevance of zebra fish as model organism in research.

#### Unit 1: Systematics, Morphology and Physiology

Systematic classification of native/exotic fishes (upto classes), Types of fins and their modification; Locomotion in fishes; Hydrodynamics; Types of scales, Use of scales in classification and determination of age of fish; Gills and gas exchange; Swim bladder; Reproductive strategies (Special reference to Indian fishes); Electric organs; Bioluminescence; Mechanoreceptors; Schooling; Migration

#### Unit 2: Fisheries



Inland fisheries; Marine fisheries; Environmental factors influencing the seasonal variation in fish; Fishing crafts and Gears; Depletion of Fisheries resources; Fisheries laws and regulations.

### **Unit 3: Aquaculture**

Sustainable aquaculture; Extensive, semi-intensive and intensive culture of fish; Polyculture; Composite fish culture; brood stock management; Induced breeding of fish; Management of fin fish hatcheries; Preparation and maintenance of fish aquarium. Factors affecting aquaculture.

### **Unit 4: Fish Pathology and Transgenesis**

Fish diseases: bacterial, viral and parasites; Preservation, diagnosis and treatment, Processing of harvested fish, Fishery byproducts; Transgenic fish, zebrafish as a model organism in research.

### **PRACTICAL**

1. Study of Petromyzon, Myxine, Pristis, Chimaera, Exocoetus, Hippocampus, Gambusia, Labeo, Heteropneustes, Anabas
2. Study of different types of scales (Through permanent slides and photographs)
3. Study of crafts and gears used in fisheries.
4. Water quality criteria for aquaculture: assessment of pH, conductivity, total solids and total dissolved solids.
5. Study of air breathing organs in Channa, Heteropneustes, Anabas and Clarias.
6. Demonstration of induced breeding in fishes (Virtual).
7. Demonstration of parental care in fishes (Virtual).
8. Project report on a visit to any fish farm/ pisciculture unit/ zebrafish rearing lab

## **PRACTICAL COURSE OUTCOMES**

- Know about the morphological features of fish specimens.
- Observe and learn about scales and patterns.
- Conduct and gain knowledge about water quality for aquaculture.
- Observe and know about different types of crafts and gears used in fishery.

### **TEXT BOOKS**

1. Q Bone and R Moore (2008), Biology of fishes, Taylor and Francis group, CRC Press, UK
2. S.S. Khanna and H.R. Singh (2014) A textbook of fish biology and fisheries, Narendra Publishing House, 3rd edition.

### **SUGGESTED READINGS**

1. D H Evans and J D Claiborne, The Physiology of fishes, Taylor and Francis group, CRC, UK
2. R J Mogdans and B G Kapoor, The senses of fish: Adaptations for the reception of natural stimuli, Springer, Netherland 28

3. C B L Srivastava, Fish biology, Narendra Publishing House 4. J R Norman, A History of fishes, Hill and Wang Publishers.

**MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	4	4	4	4	4	2	4	2	2
CO2	5	4	4	4	4	4	2	4	2	5
CO3	5	4	4	4	5	4	4	4	2	5
CO4	5	4	4	4	5	4	4	4	2	5

**Discipline Specific Elective Paper-IV**

**Economic Zoology**

**COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Describe varieties of honeybee and procedures of apiculture.
- Know about different types of silk and techniques involved in rearing and harvesting silk from silkworms.
- Describe about breeding techniques, preparation and maintenance of ponds and prawn farming.
- Understand the commercial importance of dairy and poultry, and learn about its management and business plan.

**Unit 1: Bee-keeping and Bee Economy (Apiculture)**

Varieties of honey bees and Bee pasturage; Setting up an apiary: Langstroth's/Newton's hive, bee veil, brood and storage chambers, iron frames and comb sheets, drone excluder, rearing equipments, handling of bees, artificial diet; Honey extraction techniques; Physico-chemical analysis of honey; Other beneficial products from bee.

**Unit 2: Silk and Silk Production (Sericulture)**

Different types of silk and silkworms in India; Rearing of Bomby x mori, Rearing racks and trays, disinfectants, rearing appliances, black boxing, Chawki rearing, bed cleaning, mountages, harvesting of cocoons; Silkworm diseases: Pebrine, Flacherie, Grasserie, Muscardine and Aspergillosis, and their management; Silkworm pests and parasites: Uzi fly, Dermestid beetles and their management; Silk reeling techniques and Quality assessment of silk fibre.

**Unit 3: Aquaculture**

Induced breeding of fish; Management of hatchery of fish; Management of nursery, rearing and stocking ponds; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish; Fishery by-products. Prawn farming; Culture of crab; Pearl culture.

#### **Unit 4: Dairy and Poultry Farming**

Introduction; Indigenous and exotic breeds; Rearing, housing, feed and rationing; Commercial importance of dairy and poultry farming; Varietal improvement techniques; Diseases and their management; Dairy or poultry farm management and business plan; Visit to any dairy farm or Poultry farm.

#### **PRACTICAL**

1. Submission of report on anyone field visits related to Aquaculture/Apiculture/Sericulture/Poultry/ Dairy farm.
2. Study of different types of bees (Queens, Drones and Worker bees).
3. Study of different types of silk moths.
4. Study of different types of pearls.
5. Study of different types of fish diseases.
6. Identification of different types of scales in fishes.
7. Study of different types of fins.
8. Study of different modified structures of fishes (Saw of sawfish, Hammer of hammer head fish, tail of sharks etc.)
9. Identification of various types of natural silks.

#### **PRACTICAL COURSE OUTCOMES**

- Know about diversity of bees.
- Identify different types of fish scales.
- Learn about pearls and pearl culture.
- Identify and describe different types of fins.

#### **TEXT BOOKS**

1. Sarkar, Kundu and Chaki. (2014)Introduction to Economic Zoology. NCBA Publisher.

2. T.V.R. Pillay (Author), M.N. Kutty (2011) Aquaculture: Principles and Practices, Wiley India Pvt Ltd; Second edition

### **SUGGESTED READINGS**

1. Dhyan Singh Bisht, Apiculture, ICAR Publication.
2. Dunham RA (2004) Aquaculture and Fisheries Biotechnology – Genetic Approaches. CABI publications, U.K.
3. Hafez ESE (1962) Reproduction in Farm Animals. Lea and Fabiger Publishers.
4. Knobil E and Neill JD (2006) The Physiology of Reproduction. Vol.2. Elsevier Publishers, USA.
5. Prost PJ (1962) Apiculture. Oxford and IBH, New Delhi.
6. Singh S. Beekeeping in India, Indian council of Agricultural Research, New Delhi.
7. Srivastava CBL (1999) Fishery Science and Indian Fisheries. Kitab Mahal publications, India.

### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>5</b>
<b>CO2</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>5</b>
<b>CO3</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>5</b>
<b>CO4</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>5</b>

**OR**

### **Project Work**

Each student has to undertake a project work under the guidance of a teacher and submit the project report in the form of a thesis. There will be a presentation of the project work before an external examiner.

**Generic Elective Paper I/(A1/B1)**

**ZOOLOGY**

## **Animal Diversity**

### **COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Appreciate the diversity of non-chordates living in varied habit and habitats.
- Critically analyse the organisation, complexity and characteristic features of chordates making them familiar with the morphology and anatomy of representatives of different classes.
- Understand different adaptive features and special techniques of each phyla.
- Getting familiarized with the morphology and anatomy of representatives of different phyla.

#### **Unit 1: Protista, Porifera, Radiata, Aceolomates and Pseudocoelomates**

General characters of Protozoa; Life cycle of Plasmodium, General characters and canal system in Porifera, General characters of Cnidarians and polymorphism, General characters of Helminthes; Life cycle of Taeniasolium, General characters of Nemethehelminthes; Parasitic adaptations

**Unit 2: Coelomate Protostomes, Arthropoda, Mollusca and Coelomate Deuterostomes** General characters of Annelida, Metamerism, General characters, Social life in insects, General characters of mollusca, torsion in gastropod, pearl formation, General characters of Echinodermata, larval form in Echinodermata.

#### **Unit 3: Protochordata , Pisces, Amphibia**

Salient features, Osmoregulation, Migration of Fishes, General characters, Adaptations for terrestrial life, Parental care in Amphibia.

#### **Unit 4: Reptiles, Aves and Mammals**

Amniotes, Origin of reptiles, Terrestrial adaptations in reptiles, Origin of birds; Flight adaptations, early evolution of mammals; Primates; Dentition in mammals.

### **PRACTICAL**

1. Study of following specimens: Non Chordates: Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, T. gigas, Limulus, Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias and Antedon. Chordates: Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds-(Crow, duck, Owl), Squirrel and Bat.

2. Study of following Permanent Slides: Cross section of Sycon, Sea anemone and Ascaris(male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva

3. Temporary mounts of Septal & pharyngeal nephridia of earthworm. Unstained mounts of Placoid, cycloid and ctenoid scales.

### **PRACTICAL COURSE OUTCOMES**

- Identify and distinguish the non-chordate specimens.
- Identify and distinguish the chordate specimens.
- Identify and distinguish the permanent slides of allotted non-chordates.
- Prepare temporary mount of septal and pharyngeal nephridia of earthworm and scales of fishes and describe them.

### **TEXT BOOKS**

1. Kotpal RL. (2016) Modern Textbook of Zoology –Vertebrates; Rastogi Publications – Meerut. 2. Kotpal RL.(2016) Modern Textbook of Zoology – Invertebrates; Rastogi Publications – Meerut.

### **SUGGESTED READINGS**

1. Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
2. Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
3. Raven, P.H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications, New Delhi.
4. Kardong, K.V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.

### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>4</b>	<b>5</b>
<b>CO2</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>CO3</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>CO4</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>4</b>

### **Generic Elective Paper II/(A2/B2)**

### **Food, Nutrition And Health**

## **COURSE OUTCOMES**

Upon completion of this course, students will be able to:

- Have a better understanding of the association of food and nutrition in promoting healthy living.
- Think more holistically about relationship between nutrition science, social and health issues
- Know about cause, prevention and treatment of various diseases.
- Describe pathways and mode of transmission of infections and food related diseases.

### **Unit 1: Basic concept of food and nutrition**

Food Components and food-nutrients, Concept of a balanced diet, nutrient needs and dietary pattern for various groups, adults, pregnant and nursing mothers, infants, school children, adolescents and elderly

### **Unit 2: Nutritional Biochemistry**

Carbohydrates, Lipids, Proteins- Definition, Classification, their dietary source and role  
Vitamins- Fat-soluble and Water-soluble vitamins- their dietary source and importance  
Minerals- Iron, calcium, phosphorus, iodine, selenium and zinc: their biological functions

### **Unit 3: Health Introduction to health**

Definition and concept of health, Major nutritional Deficiency diseases- Protein Energy Malnutrition (kwashiorkor and marasmus), Vitamin A deficiency disorders, Iron deficiency disorders, Iodine deficiency disorders- their causes, symptoms, treatment, prevention and government programmes, if any. Life style related diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention through dietary and lifestyle modifications, Social health problems- smoking, alcoholism, drug dependence and Acquired Immuno Deficiency Syndrome (AIDS) - their causes, treatment and prevention, Common ailments- cold, cough, and fevers, their causes and treatment.

### **Unit 4: Food hygiene**

Potable water- sources and methods of purification at domestic level Food and Water borne infections: Bacterial infection: Cholera, typhoid fever, dysentery; Viral infection: Hepatitis, Poliomyelitis, Protozoan infection: amoebiasis, giardiasis; Parasitic infection: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention, Brief account of food spoilage: Causes of food spoilage and their preventive measures

## **PRACTICAL**

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric
3. Estimation of Lactose in milk
4. Ascorbic acid estimation in food by titrimetry

5. Estimation of Calcium in foods by titrimetry

6. Study of the stored grain pests from slides/ photograph (*Sitophilus oryzae*, *Trogoderma granarium*, *Callosobruchus chinensis* and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.

7. Project- Undertake computer aided diet analysis and nutrition counselling for different age groups.

OR Identify nutrient rich sources of foods (fruits and vegetables), their seasonal availability and price OR Study of nutrition labeling on selected foods

### **PRACTICAL COURSE OUTCOMES**

- Estimate Lactose in milk and define the properties.
- Detect food adulteration and learn about common adulterants
- Estimate calcium in foods by titrimetry.
- Analyse and undertake projects about seasonal vegetables and nutritional content of foods.

### **TEXT BOOKS**

1. Mudambi, SR and Rajagopal, MV (2018). Fundamentals of Foods, Nutrition and Diet Therapy; Sixth Ed; New Age International Publishers.

2. Bamji MS, Rao NP, and Reddy V.(2017) Text Book of Human Nutrition; Oxford & IBH Publishing Co. Pvt Ltd., 4th edition

### **SUGGESTED READINGS**

1. Srilakshmi B. Nutrition Science; 2002; New Age International (P) Ltd.
2. Srilakshmi B. Food Science; Fourth Ed; 2007; New Age International (P) Ltd.
3. Swaminathan M. Handbook of Foods and Nutrition; Fifth Ed; 1986; BAPPCO

### **MAPPING FOR COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

<b>CO/PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>
<b>CO1</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>5</b>
<b>CO2</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>5</b>
<b>CO3</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>5</b>
<b>CO4</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>2</b>	<b>4</b>	<b>5</b>	<b>5</b>	<b>5</b>